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Memo

date: *November 18, 2008*

to: *RSC*

from: *D. Beavis* DB

subject: *Proposed Changes to the Radiation Protection of Thompson Road*

Introduction

Several changes are proposed for the area of Thompson Road that crosses over the RHIC injection arcs. Depending on the relative benefit from the changes the area could be made an Uncontrolled Area allowing the road to be open to vehicular and foot traffic or the area could remain as a Controlled Area during RHIC operations, but the chipmunks removed from the interlocks thereby decreasing the risk of downtime due to device failure. There is the possibility of configuring the roadway as an Uncontrolled Area and not having interlocking chipmunks. This was not proposed at this time to allow experience to be gained from using monitor programs for detecting and reducing beam losses in the RHIC arcs.

Recommendations

It is recommended that the section of Thompson Road over the RHIC X and Y injection be changed to an Uncontrolled Area during RHIC operations.

It is recommended that the chipmunks be relocated to be as close to the road as possible on each side. As part of this plan it is proposed that the four interlocking chipmunks remain in the area to monitor the roadway. The area to the north of Thompson Road should remain a Controlled Area.

It is recommended that a monitor program using loss monitors and/or current transformers be used to alert operators to large beam losses in the RHIC arcs.

It is recommended that the four chipmunks be removed from the interlock system if it is decided that the road should remain closed and posted as a Controlled Area during operations.

It is recommended that monitor TLDs be placed as close to the road as possible to monitor the dose at Thompson road.

Justification

There are now approximately 10 years of experience in operating the transfer line and RHIC. There have been changes to the operational programs and the administrative processes that we take credit for in operating the machine. In addition, it is not expected that the AGS will be extracting high intensity protons into the U line for the immediate future, which means the risk of high intensity protons faulting under Thompson road are not a realistic concern.

The committee accepted[1] a dose from losses under Thompson Road of 1.5 microrem per 10^8 Au ions or 10^{10} protons.

The maximum intensity for Au transfers to RHIC is 4 bunches of $2*10^9$ Au ions per AGS cycle. This has never been achieved, but will be used to examine routine and fault conditions for Au beam under Thompson Road.

Fault duration	**Lost Au ions**	**Dose on Thompson Rd. (mrem)**
1 cycle	$8*10^9$	0.12
30 cycles (fill one ring)	$240*10^9$	3.6
1200 cycles (an hour)	$9.6*10^{12}$	144

Routine operations[2] were expected to have a maximum routine loss of $8.28*10^8$ Au ions at a local point. Based on the dose rate accepted from the fault studies this corresponds to 0.012 mrem/hr. For a person standing over the road for 2000 hours in a year during transfers this would give 25 mrem in a year. With an occupancy factor of 1/16 the dose would be 1.6 mrem in a year. The use of 2000 hours of occupancy with an occupancy factor 1/16 is not realistic, but is certainly conservative. The loss scenario had an estimated integrated loss of Au in a single location of $8.78*10^{11}$ Au ions per year. With around the clock operations this would give an additional reduction factor of 0.125 for yearly exposure (1/4 due to 40 hours/week verses 168 and 1/2 since less beam per year than used above). The dose from routine operations and losses is well within the prescribed limits for an uncontrolled area.

Protons are delivered to RHIC in single bunches of less than $2*10^{11}$ 22 GeV protons per AGS cycle. The table below provides the dose on Thompson Road for lost protons.

Fault duration	**Lost Protons**	**Dose on Thompson Rd. (mrem)**
1 cycle	$2*10^{11}$	0.03
120 cycles (fill one ring)	$240*10^{11}$	3.6
1200 cycles (an hour)	$2.4*10^{14}$	36

The routine loss for protons would have a maximum estimated dose of 0.005 mrem in an hour on Thompson road. The routine losses are lower than that for Au operations and are not an issue for an uncontrolled area.

The potential dose during a fault was the main concern that warranted making this area a controlled area in the past. At the time there was high intensity proton beams being used by both the AGS slow beam area and by the g-2 experiment at the front end of the U line. Therefore, there was a risk that high intensity protons could reach the W line and potentially fault under Thompson Road. This risk was physically possible, but always very small. This risk no longer exits so that re-evaluation of the potential dose for protons faults is warranted.

The calculations of reference 2 can be used to examine the effectiveness of the chipmunks to detect beam losses under the road. A dense lattice[3] is estimated to produce a radiation pattern that has a width of 23 feet at 1/3 of the peak dose and 36 feet at 1/10 of the peak dose. The loss of 120 bunches of Au under the road would cause a dose in the peak of 3.6 mrem with a time duration of 90 seconds corresponding to a dose rate of 144 mrem/hr. The 2.5 mrem/hr interlock level on the chipmunks would respond to a loss location in a band of length 56 feet long. The X arc has more tunnel length under the road than the Y arc. For both the arcs it is important although not necessarily required to move the chipmunks as close to the road as possible so that they have an optimal sensitivity to faults under the roadway should the roadway be made an uncontrolled area.

The geometry of the tunnel relative to the road makes it more difficult to place the chipmunks close together for the X arc than the Y arc. Presently, the chipmunks in the X (Y) arc are approximately 100 (70) feet apart. The present positions are not ideal for monitoring faults under the road. The chipmunks can be relocated to decrease the distance between them and this is recommended if they are to remain in the area for monitoring faults. Loss monitors would be more effective in monitoring faults, although not at the certification level of the chipmunk system.

It is expected[4] that the loss monitor system for the arcs could easily detect losses of the order of 5% of the beam and promptly alert the operators. If the loss monitor system is used to limit losses in the arcs under the road to less than 5% then the potential dose to personnel on the road would be limited to 0.18 mrem for the fill of one RHIC ring. This is well below the committee limit of 20 mrem of dose received in an uncontrolled area from a fault.

The dual B15 current transformers limit the proton beam to $2.5*10^{12}$ protons per AGS cycle. At this intensity the dose from a single bunch would be 0.38 mrem. The attempt to fill RHIC with 120 bunches that would fault under Thompson road would produce 45 mrem in about 6 minutes. It is highly doubtful that the operators would miss the fact that the being was not making it into RHIC. Most likely they would stop the injection process in a few cycles without an alarm program. It is also doubtful that this transport of this much beam could occur to the W dump without the operations staff knowing. A monitor program to examine losses in the arcs as well as the beam intensity extracted into the W line should be sufficient administrative controls to prevent such an occurrence.

References

1. RSC Minutes of April 2, 2001 and memorandum from J.W. Glenn and A.J. Stevens to D. Beavis on Dec. 12, 2000.
2. A.J. Stevens, "Analysis of Radiation Levels Associated with Operation of the RHIC Transfer Line", AD/RHIC/RD-83 Dec. 1994.
3. See figure 5 of reference 2.
4. G. Marr private communication.

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